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NOZZLE

Field of technology

The invention relates to the coating of a moving web-like material using high-pressure techniques and it concerns the nozzle used in such coating. The invention can be used especially in paper coating.

Technical background

In paper coating, a coating composition is applied to the paper surface with a special view to enhancing the printing characteristics of paper. Conventionally, presses, knife applicators and film-transfer devices have been used for coating. These techniques are difficult to implement reliably especially when an increase in the running speed or coating of very thin paper is required.

Spray coating has appeared as the most recent coating technique. It has the special advantage of not requiring any mechanical coating means, such as an abrasive knife or rotating rod, in contact with the web. High-pressure spray techniques have proved particularly promising. Here the coating composition alone, without any gaseous medium, is driven under high pressure through a nozzle with small orifices, the composition being diffused (atomised) into small droplets. The pressure may be e.g. in the range from 1 to 200 MPa and the nozzle orifice area e.g. in the range from 0.02 to 0.5 mm^2. A typical maximum droplet size is approx. 100 µm. Such an apparatus comprises a nozzle array having one or more nozzle rows transverse to the path and consisting of a plurality of nozzles. The nozzles are disposed so as to cover the web as evenly as possible with the jets. Then jets formed by adjacent nozzles in a nozzle row overlap appropriately at their edges. The jet shape provided by the nozzle depends on the shape of the nozzle orifice. The usual aim is a fan-shaped jet, which is larger in the transverse direction than in the longitudinal direction of the web. Then the nozzle orifice is accordingly oval. To achieve regular coating, the fans are preferably disposed obliquely to the direction of travel of the web.

Spray coating of paper is described e.g. in the papers FI-B-108061 (corresponding to WO 9717036) and Nissinen V, OptiSpray, the New Low Impact Paper Coating Technology, OptiSpray Coating and Sizing Conference, Finland, 15 March 2001.

Nozzles can be manufactured by making a piece of a suitable material, e.g. a highly wear-resistant material, the piece having a tapered duct ending in a closed tip, the desired nozzle orifice being subsequently machined in the tip. An oval orifice is provided if a transverse V-shaped groove is machined in the tip. The nozzle material may be e.g. highly wear-resistant tungsten carbide composition (such as WC + Co).

General description of the invention

A nozzle as defined in claim 1 has now been invented for use in the coating of web-like material. The other claims describe some preferred embodiments of the invention.

The nozzle is made by machining in the closed tip of the tapered duct a transverse V-shaped groove at a machining angle in the range from 25 to 50°, such as 35 to 45°. The angle of the groove has an impact on the shape of the oval flow opening thus produced and hence on the shape of the jet produced. The nozzle of the invention provides a fairly rounded fan-shaped jet with soft edges, thus facilitating overlapping of adjacent jets so as to achieve optimally regular coating.

The flow duct is preferably circular in cross-section and straight. Before machining, the duct tip has preferably the shape of a spherical surface.

Enlargement of the V-shaped groove has proved to increase the wear resistance of the nozzle. In high-pressure spraying, flow rates are high (e.g. of the order of about 100 m/s), and coating compositions usually comprise solid substances (e.g. calcium carbonate), which substantially increase the wear of nozzles.

The nozzle may comprise a preliminary nozzle. It acts as a preliminary diffuser of the jet. The preliminary nozzle may especially comprise an expanding flow channel. It is particularly useful for enhancing the wear resistance of the nozzle. In a number of embodiments, the flow channel of the preliminary nozzle may expand or taper in the flow direction.

The size (diameter of orifice) of the preliminary nozzle may be e.g. in the range from 0.1 to 1 mm, typically in the range from 0.25 to 0.55 mm. The area of the preliminary nozzle orifice may account for e.g. at the most 50 %, typically at the most 20 % of the orifice area of the nozzle proper (secondary nozzle).

Also, a nozzle has now been invented, in which the ratio of the maximum diameter to the minimum diameter of the oval orifice is markedly more than 1, such as 1.2 to 3, especially 1.5 to 2.5. The nozzle orifice may have dimensions e.g. in the range from 1 to 0.3 mm x 0.5 to 0.1 mm, typically 0.75 to 0.4 mm x 0.35 to 0.15 mm.

Also, a nozzle has now been invented that comprises a secondary nozzle, a tapered flow duct and a preliminary nozzle connected in front of this, the area of the flow opening of the preliminary nozzle being at the most 1.1 times the transverse area of the flow opening of the secondary nozzle. Optimally, the area of the flow opening of the preliminary nozzle is at the most equal to the transverse area of the flow opening of the secondary nozzle. Such a preliminary nozzle allows for increased wear resistance of the preliminary nozzle.

The nozzles of the invention can be used in the coating of paper, such as printing paper and cardboard, for instance.

Description of the drawings

Some embodiments of the invention are described in detail below. The accompanying drawings pertain to the written description.

Figure 1 shows a nozzle of the invention and a preliminary nozzle to be connected to the nozzle.

Figure 2 shows the volume flow of the nozzle combination in figure 1 as a function of time.

Detailed description of some embodiments of the invention

The nozzle of figure 1 comprises a secondary nozzle 1 and a preliminary nozzle 2.

The secondary nozzle 1 has been manufactured by first making a piece having a straight tapered flow duct, which is circular in cross-section and comprises a closed tip shaped as a spherical surface. In the centre of the tip, a transverse V-shaped groove has been machined so as to provide a nozzle orifice 3 with the desired transverse area. The nozzle orifice is oval and it produces a fan-shaped jet.

The preliminary nozzle 2 comprises an expanding flow duct, whose feed orifice 4 is circular.

The grinding angle of the nozzle orifice 3 influences the shape of the nozzle orifice and the jet obtained with this. The smaller the grinding angle, the flatter the shape and the sharper the edge of the fan-shaped jet produced. The fan edges may further comprise forwardly oriented profile peaks. An enlarged grinding angle will expand the oval shape of the flow cross-section, thus providing a jet profile which is rounder and better fitting with the profile of another jet.

In accordance with the invention, the grinding angle is in the range from 25 to 50°, such as 35 to 45°. Accordingly, the ratio of the major axis to the minor axis in the oval orifice is in the range from 1.2 to 3, such as 1.5 to 2.5. The fan angle of the jet thus produced is about 90°. The angle between ground surface and the surface of the flow duct is preferably at least 90°, typically from 100 to 150°.

At a coating station, there may be nozzles aligned in one single row at e.g. 60 mm intervals at a distance of about 100 mm from the web. The nozzles are preferably disposed overlapping at a suitable angle with a view to providing optimally regular double coverage.

It has also been found that the corner of the lower edge 5 of the grinding side is most critical in terms of wear. This corner is rounded during the wear of the nozzle, resulting both in a larger orifice area and altered orifice geometry and consequently also in a different jet shape. The originally oval orifice will approach a rectangular shape. The larger the grinding angle, the lower the abrasion.

The impact of abrasion was studied with regard to a nozzle of figure 1 by spraying calcium carbonate paste (50 % dry matter content) under a pressure of 10 MPa. The volume flow (ml/s) as a function of time (h) is indicated in figure 2. The volume flow increases very strongly at the outset. However, at the end of about 95 hours, the growing rate is distinctly stabilised. At 336 hours, the preliminary nozzle was replaced, resulting in a 32 % drop in the volume flow, which still was 34% higher than the starting level. Subsequently, the abrasion curve will be slightly gentler than that of two new nozzles. This is presumably due to the fact that a new preliminary nozzle has a smaller orifice than that of a worn secondary nozzle. As a preliminary nozzle has larger area of wear, the secondary nozzle will wear at a slower rate. As the abrasion curve stabilises, the sizes of the nozzle orifice areas approach each other. As the secondary nozzle was replaced at 670 hours, the volume flow started to grow strongly again, thus supporting the assumption above.

When a preliminary nozzle of one size category below was fitted in the nozzle, abrasion became markedly slower. Over two weeks (336 h), the volume flow increased by 25 % alone, and this can be readily compensated for with the aid of pumping pressure.

The area of the flow orifice of a preliminary nozzle should not be more than 1.1 times the transverse area of the flow orifice of the secondary nozzle. The area of the flow orifice of the preliminary nozzle is preferably at the most equal to the transverse area of the flow orifice of the secondary nozzle.